Pest Management Grants Final Report

98-0280

Use of Sodium Bicarbonate in a High Pressure Scale Washer for the Control of Postharvest Mold of Citrus Fruit

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DISCLAIMER

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Use of Sodium Bicarbonate in a High Pressure Scale Washer to Clean Citrus Fruits (contract # 98-0280)

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SUMMARY
Post harvest green mold on oranges was reduced by about 80% by washing the fruit with a 3% sodium bicarbonate and 200 ppm chlorine solution at a commercial citrus packinghouse. (Golden State Citrus Packers in Woodlake, California) Fruit was also treated with an OPP solution, a standard packinghouse treatment, and rinsed. Fruit was also dipped in 3% sodium bicarbonate, 200ppm chlorine and water chlorinated at 200 ppm. Fruit washed with the HPSW (high pressure scale washer) and 3% sodium bicarbonate/200ppm chlorine and fruit dipped in 3% sodium bicarbonate/200ppm chlorine were superior to both the OPP treatment and the chlorine dip treatment. The HPSW treatment is a useful and practical method of achieving a high level of decay control on fruit. The concentration of sodium bicarbonate in the HPSW is normally between 1% and 3%. The solution works well in the HPSW and is not harmful for the machinery. Since most orange packinghouses have citrus HPSW this technology can be used and implemented immediately.

Green mold of citrus, caused by *Penicillium digitatum* is one of the most economically important postharvest diseases of citrus worldwide. In California, losses of about 2% and 5% of orange and lemons in storage, respectively, occur each year. The primary infection courts of *P. digitatum* are wounds on fruit inflicted during harvest and subsequent handling. Eradication of these infections is required to achieve acceptable levels of control. Currently, green mold is controlled in the United States by applications of the fungicides ortho-phenyl phenate, imazalil, and thiabendazole. New methods are needed because pathogen resistance to these chemicals has developed, and regulatory issues and public concerns about health risks of ingesting fungicide residues threaten the continued use of fungicides in the future. We evaluated compounds that have well studied environmental and animal toxicological properties and extensive precedents as

additives or natural components in foods. By selecting these compounds, we hope to facilitate their approval by minimizing health, environmental and disposal issues. A cleaning process that meets these criteria is a washing treatment that uses a high pressure scale washer (HPSW). It uses sodium bicarbonate as the washing media. Adding 200ppm sodium hypochlorite to the water sanitizes the water for soil borne bacteria and inbound pathogens. The pH of sodium bicarbonate is 8.3 and is suitable for disposal into sewage treatment systems in most areas. Sodium bicarbonate is half the sodium of soda ash. Sodium bicarbonate will start converting into sodium carbonate between 20°C and 100°C. At 20°C (68°F) it will begin to lose CO2 and at 100°C it will completely convert to sodium carbonate (Na2CO3). However at 20°C only about .15% by weight will convert to sodium carbonate. Most uses for sodium bicarbonate in the HPSW will be at ambient temperatures.

Uses of sodium bicarbonate go back several millennia. Some of the more common uses are for baking, fire fighting media, antacid tablets, effervescent salts, beverages and of course cleaning compounds.

It is thought in the application of the high pressure scale washer, the pathogen is removed from the surface of the fruit and then destroyed by the chlorine in the solution.

MATERIALS AND METHODS

Standard methods used to evaluate citrus postharvest fungicides were used (Eckert, J. W., and Brown, G.E. 1986 Evaluation of postharvest treatments for citrus fruits. Pages 92-97 in: Methods for Evaluating Pesticides for Control of Plant Pathogens. K.D. Hickey, ed. American Phytopathological Society, St. Paul, MN.) Lemons and oranges used in all

experiments were California grown and selected by hand from field bins after harvest, before any commercial postharvest treatments were applied. Lemons selected were light green to pale yellow in color and used within one or two days. Petri dishes of potato dextrose agar were inoculated with P. digitatum isolate M6R (from J.W. Eckert, University of California, Riverside) and incubated at 20°C for 1 to 2 weeks. Spores were rubbed from the agar surface with a glass rod after a small volume of sterile 0.05%Triton X-100 was added. The spore suspension was passed through two layers of cheesecloth and diluted with sterile water to density of 0.1 at 420 nm. This density contains approximately 1 million spores per ml and is recommended for evaluation of postharvest treatments to control green mold. Each fruit was wounded and inoculated once by dipping a stainless-steel rod in the spore solution and making a puncture injury 1mm wide by 2 cm deep on each fruit. The shallow wounds penetrated the albedo tissue but not the juice sacs and simulated natural inoculation. After inoculation, the fruit were incubated at 24 hours at 16 to 20°C, then the treatments were applied. The lemons were treated in plastic baskets in four or five replicates of 25 fruit each, rinsed with water, placed in plastic cavity trays, and stored 1 or 2 weeks at 15 to 20°C before the incidence of green mold infected fruit was counted.

In this test our objective is to demonstrate a simple and practical technique to apply sodium bicarbonate (SBC) for the control of postharvest decay of citrus. By combining the cleaning and the SBC application several advantages are evident; only a single filtration and chlorination system is needed, chlorination is improved when applied at a near neutral pH, because a larger amount of hypochlorite is present. At pH 8.3-8.4

approximately 13% of the hypochlorous acid is present. So at 200ppm add to the water only about 25-26 ppm of active chlorine is available. SBC can serve as a high capacity buffer to keep the solution at an optimum pH. Chlorination is needed because microbial contamination of bicarbonate salt solutions can occur, and chlorination increases the efficacy of SBC for the control of citrus green mold (Smilanick et al. 1999). Of the solutions that control green mold in use today, SBC is the most practical choice for use through a high pressure washing system. Other tank solutions approved and in commercial use (liquid lime sulfur solution, borax-boric acid mixtures, sodium carbonate, and sodium ortho-phenyl phenate) are either not compatible with chlorine or only stable at high (>10) pH.

Bicarbonates and carbonates are common food additives for leavening, pH-control, taste, texture modification and to control spoilage. They also control many plant pathogens (Smilanick et al., 1999). Regulatory barriers to their use are few; most are classified as generally recognized as safe by the US Food and Drug Administration for any applications. In 1997, the US Environmental Protection Agency declared that bicarbonates were exempt from residue tolerances on all agricultural commodities and the USDA classified many carbonates and bicarbonates as approved ingredients on products labeled "organic" in proposed regulations to standardize "organic" practices. Brief immersion of citrus fruit in solutions of sodium bicarbonate (NaHCO3) or sodium carbonate (Na2CO3, soda ash) reduces the subsequent incidence of postharvest green mold, caused by Penicillium digitatum Barger (1928) first reported its effectiveness, and its use has recently been refined and it is a common commercial practice. It is

inexpensive, poses a minimal risk of injury to the fruit, and can be a useful tool in the management of fungicide resistant isolates, which have become particularly problematic. Its effectiveness can approach that of the fungicides employed for this purpose (Smilanick et al., 1995), and in general is superior to other treatments that are alternatives to fungicides, such as heat or biological control. Sodium carbonate has particularly good eradicant activity; the incidence of infections from wounds on lemons inoculated 48 hours before treatment was reduced more than 90% (Smilanick et al., 1995). Eradicant activity is important because most infections occur through wounds inflicted during or just after harvest (Eckert and Brown, 1986), and often a day or more can elapse before treatments are applied.

In the test at Golden State Citrus Packers we compared several different treatments, sodium ortho-phenyl phenate (SOPP) spray, high pressure scale washing (HPSW) with just water, 3% sodium bicarbonate (SBC) and 200ppm sodium hypochlorite as a dip, and 3% sodium bicarbonate (SBC) and 200ppm in a high pressure scale washer. SOPP is a very common lemon and orange spray used on brushbeds in citrus packinghouses (rates are usually 1-2% in concentration at the spray bar). The 3% SBC dip with chlorine emulates a tank treatment, again, a very common practice in packinghouses. A HPSW with water alone is again a most common practice found in citrus packinghouses for all-purpose cleaning of citrus fruits. The last treatment was a 3% SBC solution in a HPSW. The water temperature for the test was 68°. The fruit was 5 days old before inoculation.

The treatments are as follows:

1) Innoculated control, no treatment
2) 200ppm chlorine in a HPSW at 100psi
3) 1.6% SOPP spray treatment applied on a roll elevator and 10 brushes followed by 200ppm chlorine in a HPSW at 100psi
4) 3% SBC with 200ppm chlorine dip in 8# mesh bags for 35 seconds

3% SBC with 200ppm chlorine in a HPSW at 100psi

The test was done with oranges randomized and stored at 42°F for 2 weeks at the Lindsay cooler. The incidence of green mold was then determined.

RESULTS

The incidence of green mold on oranges was reduced by immersion in a 3% wt/vol sodium bicarbonate solution with 200ppm sodium hypochlorite (35 second dip) by 77%. HPSW using a 3% SBC with 200ppm chlorine reduced the incidence of green mold by 78.7%. The SOPP spray at 1.6% followed by brushing and HPSW at 100psi with 200ppm chlorine had reduced green mold by only 4.5%. Washing the oranges with a HPSW using 200ppm chlorine at 100psi had 0% decay control. The SBC dip and the SBC solution in a HPSW were both equal and superior to the SOPP spray and the HPSW using water and chlorine alone.

DISCUSSION

On some earlier tests the HPSW has shown superior decay control over a tank on older fruit. Earlier tests have also shown a linearity between the concentration of the sodium bicarbonate solution and its decay control efficacy. For example a 1% SBC solution

would yield about 40% decay control whereas a 3% solution might yield 80-100% decay control. This test was designed to look at older fruit for two reasons, one was to develop a worse case scenario and second was to establish what kind of decay control you could expect for example on gassed fruit which may be 5 days old. Many earlier tests indicate decay control close to 100% on fruit only 24-36 hours old (which is normal pick-pack timeline). The screen filtration used on a HPSW to filter the water only screens it down to 75 to 150 microns. At the end of the workday if it was possible to refilter the water to 3 or less microns. You could reuse the water for several days before discharging it and filter out some of the green mold as well which is around 5 microns.

CONCLUSION

This method of using SBC in a HPSW could easily be retrofitted in most commercial citrus packinghouses. Most packinghouses already use HPSW to clean the citrus fruits to enhance the fancy to choice ratios on fruit pack-outs. By using the sodium bicarbonate in the HPSW they could achieve both cleaning and superior decay control.

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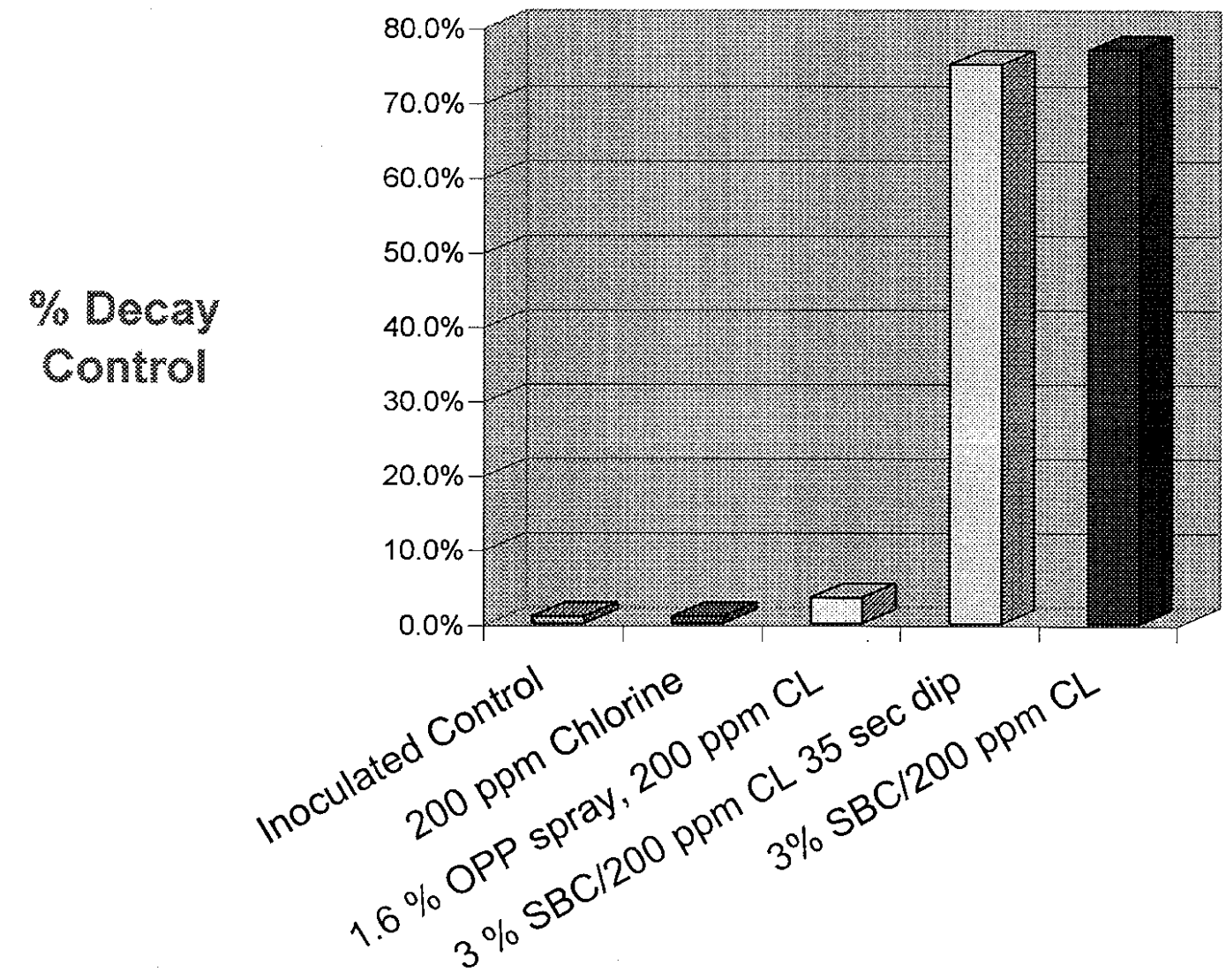
Explanation of Graphs

1. Golden State graph of DPR Test Results and results of Decay Control.
2. Graph of HPSW tests using water and chlorine alone showing the results of the Decay Control.
3. Graph of the HPSW test using 1% and 3% Sodium Bicarbonate on 5-day-old navel and lemons.
4. Mayflower – TCLA Test 1 using ½%, 1% solutions in a HPSW and comparing to a dip of 35 seconds. The HPSW was used in a low and high pressure mode.
5. Mayflower – TCLA Test #2 using solutions of 5% Borax/Boric acid, and 35% Sodium Bicarbonate on a HPSW and comparing it to the dips of soda ash, and sodium bicarbonate.
6. A graph of HPSW test using 3% Sodium Bicarbonate, and 5% Borax/Boric acid in a HPSW and comparing their results to the dips using Borax/Boric acid (5%), Sodium Bicarbonate (3%) and Soda Ash (3%) dip. In this test the Sodium Bicarbonate and Borax/Boric acid were clearly superior to the corresponding dip treatment.
7. Graph comparing ½%, 1% and 3% solutions in a HPSW and their corresponding decay control.

Table #1 Golden State Bicarbonate/Chlorine Test Feb 2000



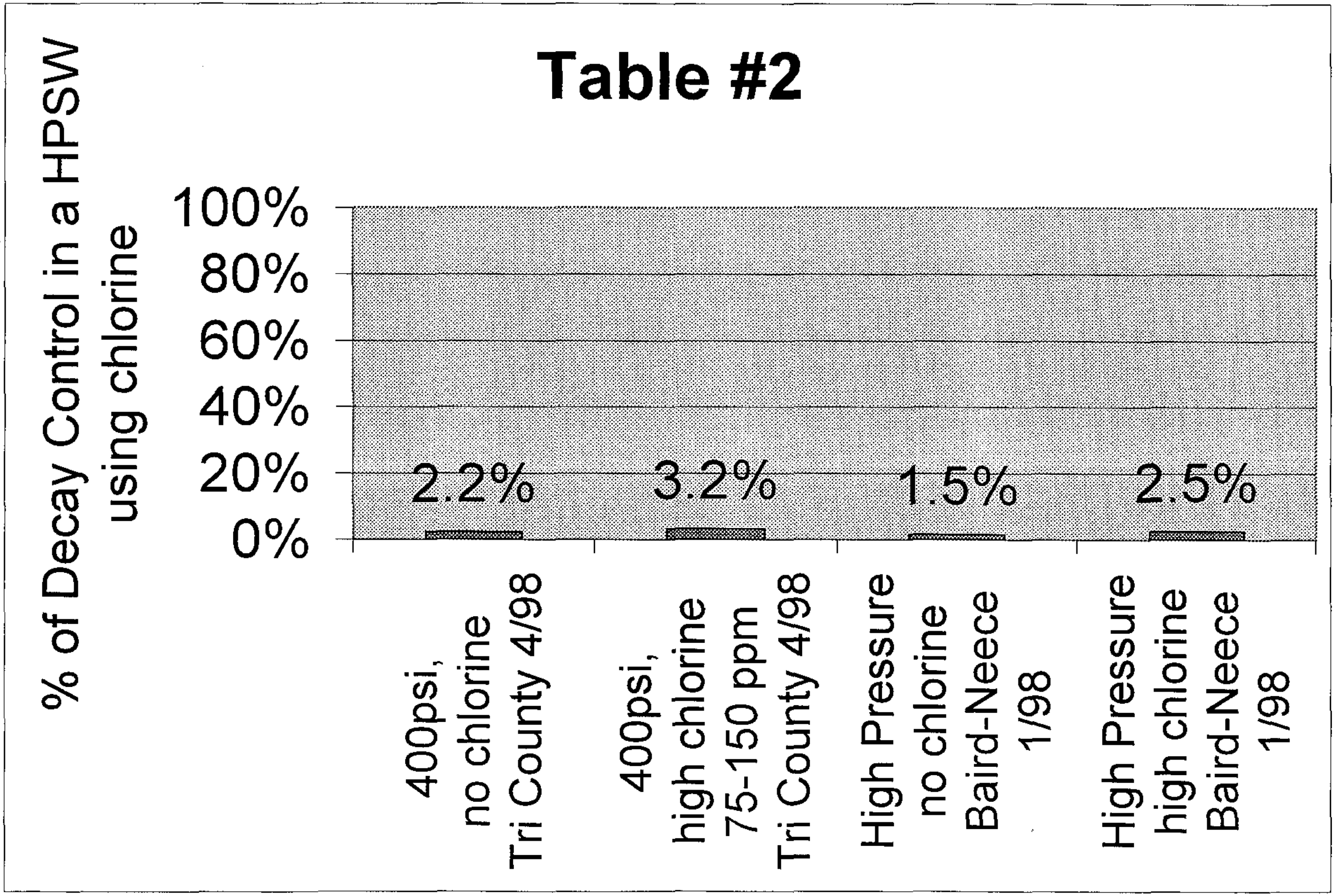


Table #2
% of Decay Control in a HPSW using chlorine
100%
80%
60%
40%
20%
0%
2.2%
3.2%
1.5%
2.5%
400psi, no chlorine Tri County 4/98
400psi, high chlorine 75-150 ppm Tri County 4/98
High Pressure no chlorine Baird-Neece 1/98
High Pressure high chlorine Baird-Neece 1/98

Table #3

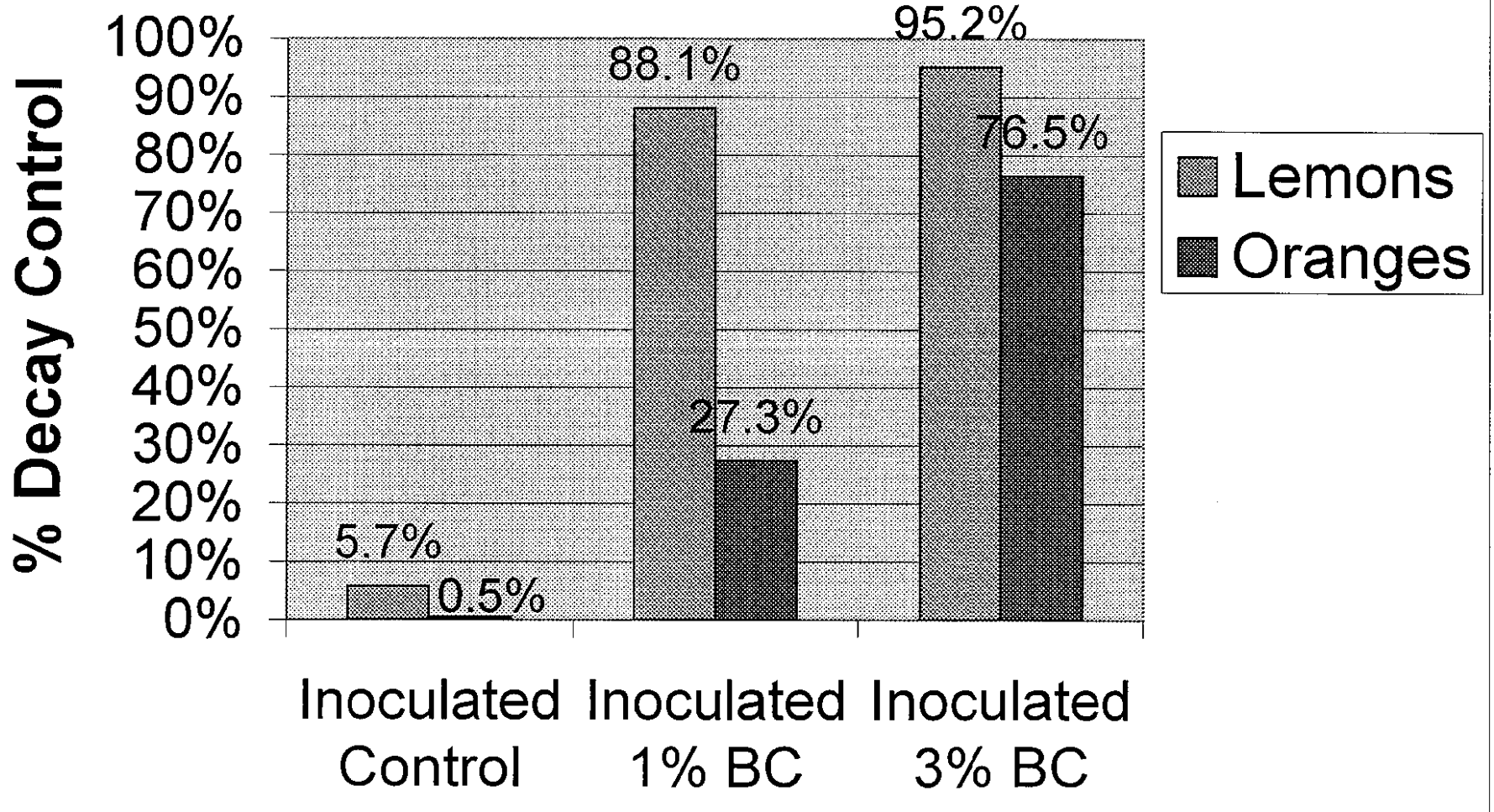
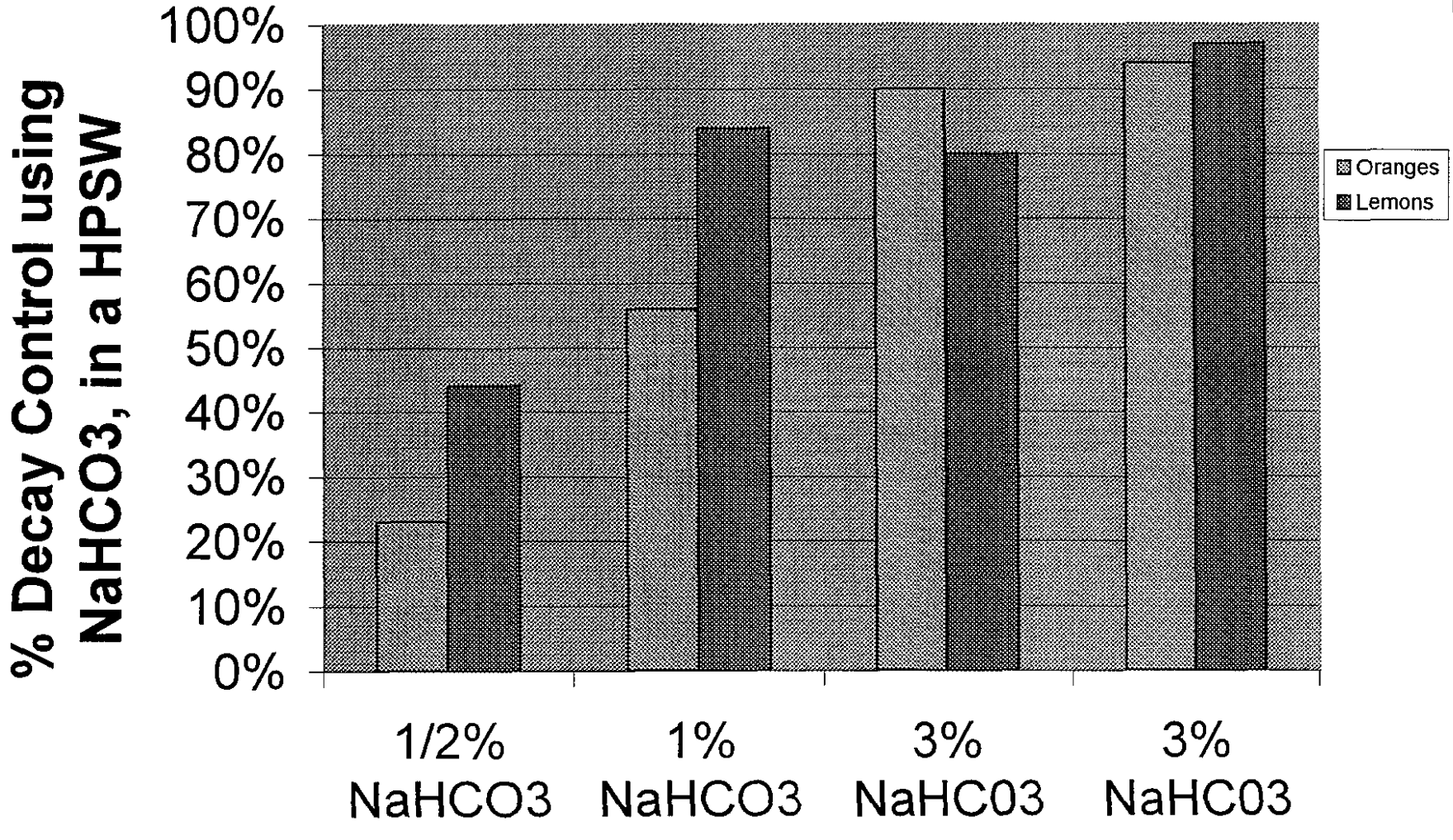
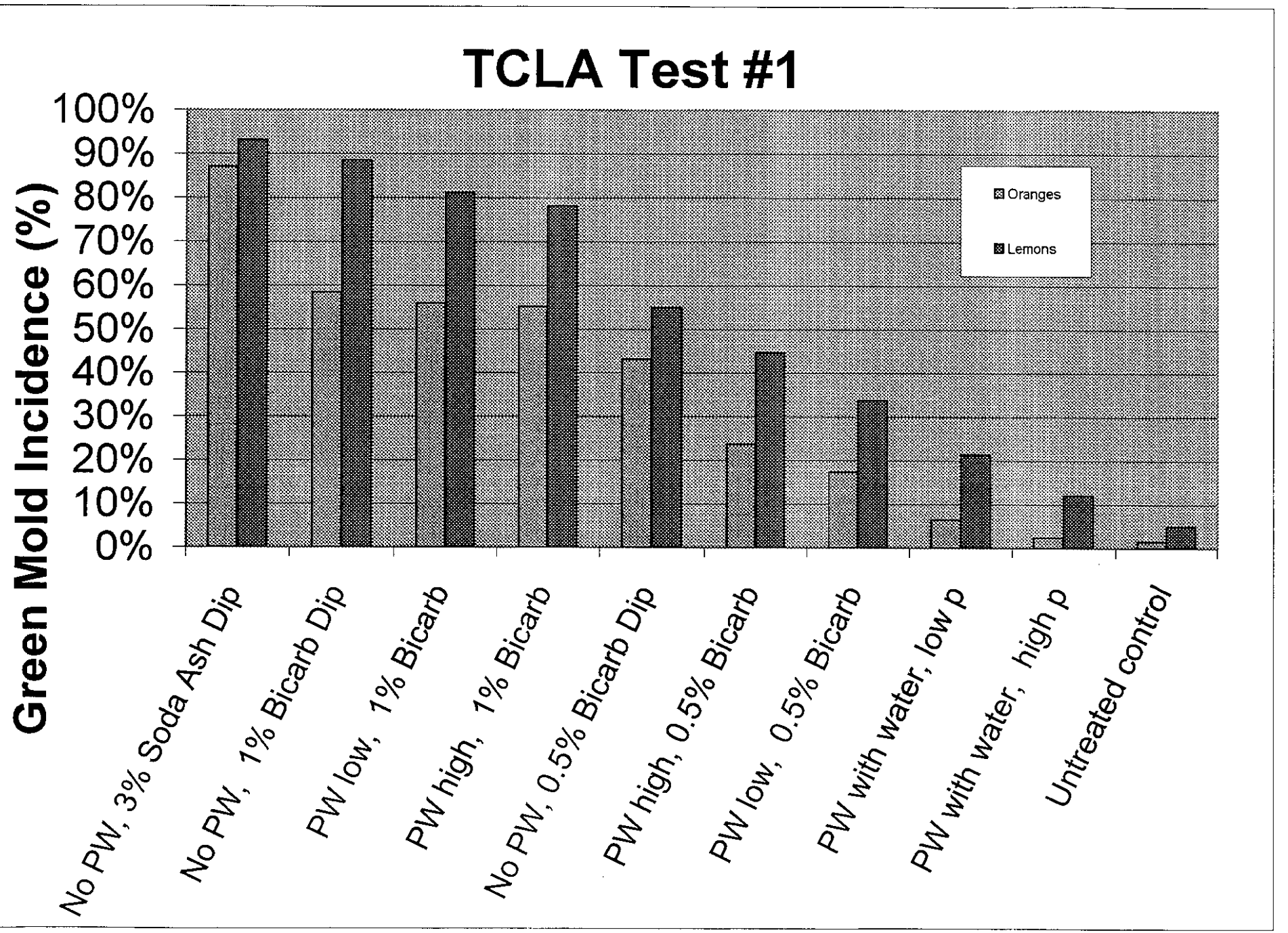
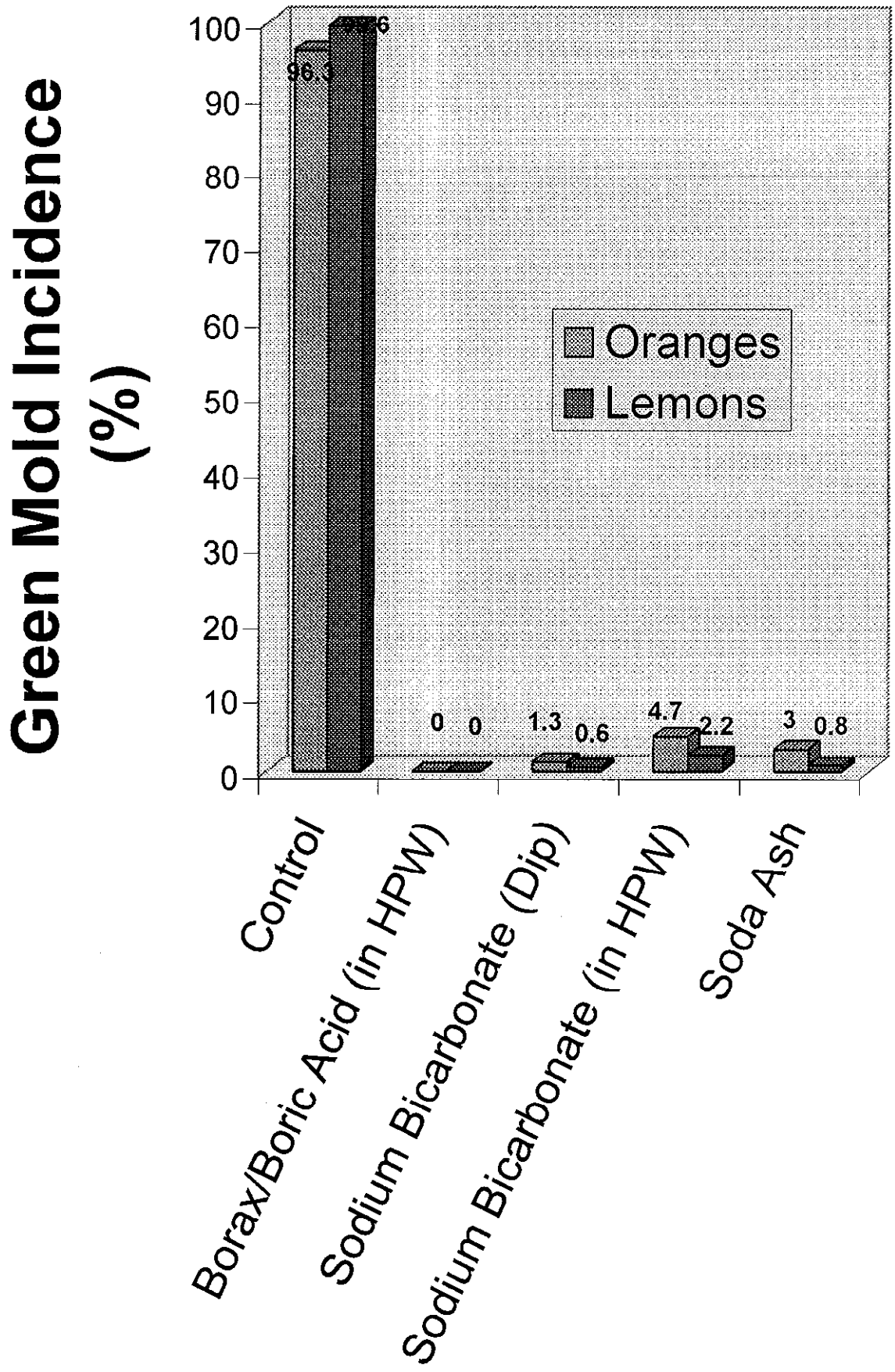

% Decay Control
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5.7%
0.5%
88.1%
27.3%
95.2%
76.5%
Lemons
Oranges
Inoculated Control
Inoculated 1% BC
Inoculated 3% BC

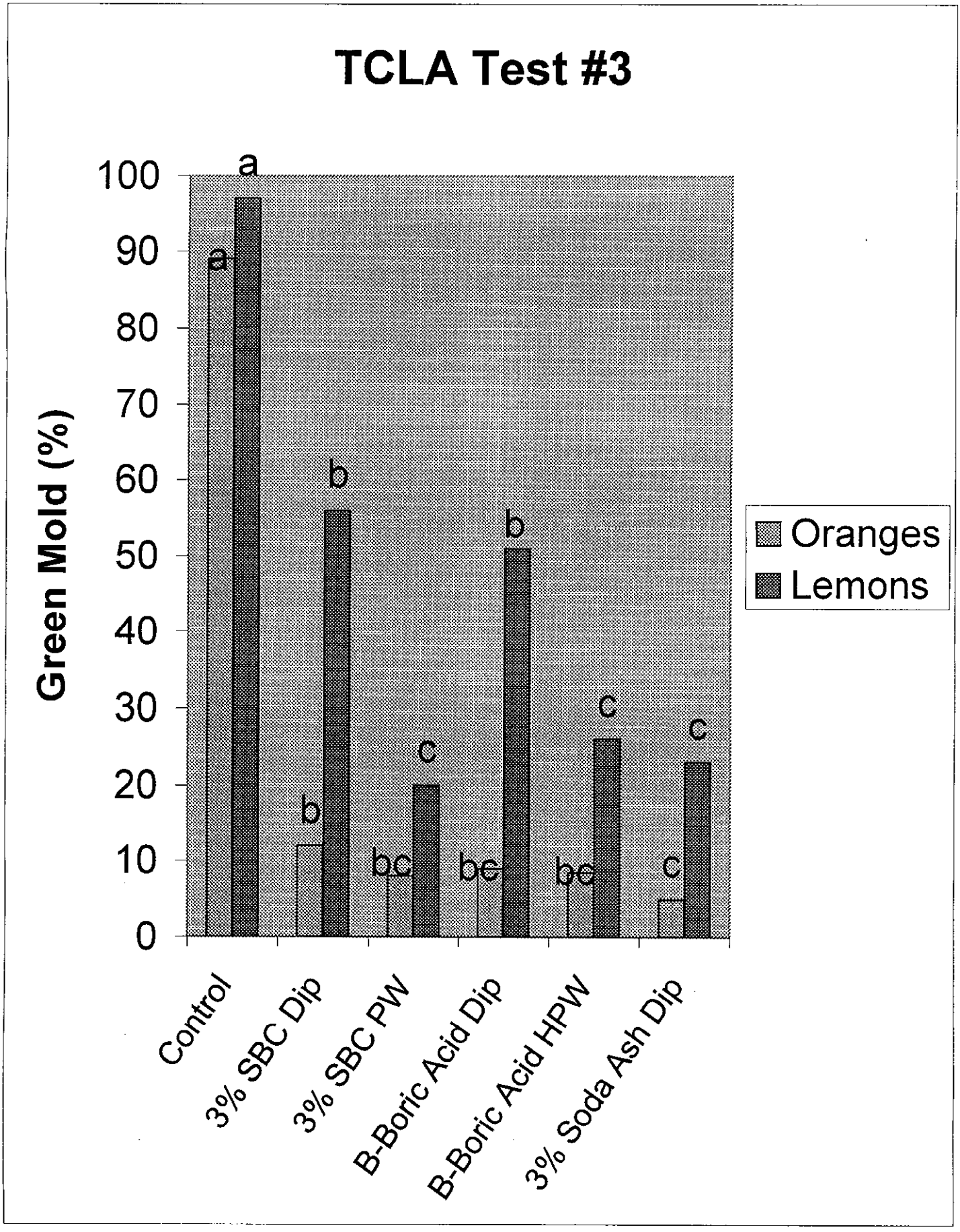
Table #4


% Decay Control using NaHCO3, in a HPSW
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1/2% NaHCO3
1% NaHCO3
3% NaHC03
3% NaHC03
Oranges
Lemons


TCLA Test #1
Green Mold Incidence (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Oranges
Lemons
No PW, 3% Soda Ash Dip
No PW, 1% Bicarb Dip
PW low, 1% Bicarb
PW high, 1% Bicarb
No PW, 0.5% Bicarb Dip
PW high, 0.5% Bicarb
PW low, 0.5% Bicarb
PW with water, low p
PW with water, high p
Untreated control

TCLA Test #2


Green Mold Incidence (%)
100
90
80
70
60
50
40
30
20
10
0
96.3
0
0
1.3
0.6
4.7
2.2
3
0.8
Oranges
Lemons
Control
Borax/Boric Acid (in HPW)
Sodium Bicarbonate (Dip)
Sodium Bicarbonate (in HPW)
Soda Ash


TCLA Test #3
Green Mold (%)
100
90
80
70
60
50
40
30
20
10
0
a
a
b
b
bc
c
bc
b
bc
c
c
Oranges
Lemons
Control
3% SBC Dip
3% SBC PW
B-Boric Acid Dip
B-Boric Acid HPW
3% Soda Ash Dip